

Competence of Biopesticide and Neem in Agriculture

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Abstract— *Neem plant is considered as the most useful traditional plant in India. The various properties of different parts of neem tree are used as insecticide, antifeedant, hormonal, antifungal, antiallergic, antidermatic, anti-inflammatory, antiscabic larvicidal and spermaticidal activity etc. In recent era the major challenge is to increase the food production without harming the environment and can control the pest. Since, last decades pesticides have become an integral component in sustainable agriculture and the modern day cultivation practices uses of chemical pesticides and fertilizers are in eliminable. Enormous use of different chemical pesticides in agricultural fields is resistant to most of the pests. So that the natural pesticides from A. indica are considered to be less harmful, biodegradability, least persistence, lest toxic to non-target organism, economic and used to combat insects, pests are not ruled out. Neem derived products play an essential role in the pest management, in agricultural fields such as crop and stored grains. Fruitful results of application of formulated neem based products in agriculture field will provide a cost effective technology to the farmers.*

Keywords— *Bio fertilizer, Biopesticides, Neem, Soil fertility.*

I. INTRODUCTION

Agriculture is a significant sector for food, fibres, bio-fuels & other products for the wellbeing of human life. In the context of the growing Indian population, apart from fulfilling the demands of food, agriculture plays vital role in improving the socio economic status of country. In the other hand, with the increase in human population along with the scarcity of land, people are using chemical fertilizers and pesticides for enhancing food productivity and crop yielding capacity which are the primary causes for the reduction in soil fertility and degradation [Liu *et al.*, 2004]. Neem plant namely *Azadirachta indica* commonly found in Indian subcontinents and belongs to family *Meliceae*. This tree grows rapidly and can reach a height of 15-20 meters in tropic and sub tropic climate, and also survive in dry and arid conditions. The barks of neem plant contain 14% of tannin; it is also strong in course fiber which is commonly used in ropes. In India 80% of neem oil is used in manufacturing of soaps. One

of the most popular dishes namely *veppampoo charu* obtained from the shoots and flowers of neem are commonly used in Tamilnadu. The neem plant is used in medical treatment, and its oil is used in insecticides, lubricants, pesticides, and in variety of diseases such as diabetes and tuberculosis. The environment is adversely affected by the use of chemical fertilizer and pesticide like water hardness, development of insect resistance, genetic variation in plant, increase in the toxic level in food chain and other human health issues like skin cancer. These also cause water pollution due to the accumulation of nitrates by the breakdown of nitrogen fertilizer. Applying high level of chemical fertilizers & pesticides on agriculture can gradually reduce the growth of beneficial microorganism in soil. To make an eco-friendly plant protection field through an integrated pest management (IPM), it is necessary to introduce the substitutes of chemical fertilizers and pesticides called bio fertilizer and bio pesticide which are the inoculants of soil microorganism, which enrich the soil nutrient level & establish the symbiotic relationship with plants by producing nitrogen & phosphorous nutrient in the soil and harnessing the foresaid challenges [Dutta, 2015]. Bio-fertilizers are the substances which contain bio-organisms which colonize and supports to promote the growth of plants by supplying the primary nutrient. They have the ability to synthesize important nutritional element from non-usable to usable form. The study says that the application of bio-fertilizer to the seed or soil improves the yield by 10-20 % without harming the soil & environment [Roychowdhury *et al.*, 2014].

II. PESTICIDES

Pesticides are toxic chemical compounds are used in agriculture, horticulture, olericulture, floriculture, to kill the pests, improve the quality of plant and increase the crop yield. Pesticides are used in public health to kill the vector of diseases such as mosquito and in agriculture to kill pests which cause crop damage. Ideal pesticides must be lethal to targeted pest but nontoxic to non-target species including man. There are two outcomes from the use of pesticide on agriculture field both beneficiaries as well as hazardous impact. Benefits of pesticide include improvement of productivity, protection of crop losses,

and vector disease control improved quality of food [Aktar *et al.*, 2009]. Pesticides can be up two types based on the presence of active ingredient, such as Synthetic pesticides and Bio pesticides:

2.1. Synthetic Pesticides:

The synthetic are placed in different groups like Organ chlorines, Organophosphates, Phenoxies, Triazines and Thiocarbamates etc. According to different survey in European nation, some pesticides have hazardous impact on food stock, soil, water level, environment and finally human. It has been reported that pesticides Acephate, chlorpyrifos, methylated chlorpyrifos, Methamidophos, Iprodione, Procymidone, Chlorothalonil, Benomyl and Moneb group have dangerous effect on fruits like apple, strawberries and grapes. Every sample contained some amount of residue of these applied pesticides [Aktar *et al.*, 2009]. These pesticides are unavoidable imputes in our ecosystem and olericulture. India used maximum amount of synthetic pesticides in comparison to world. In India, about 76% insecticides are used whereas about 44% of insecticides are used in worldwide [Mathur *et al.*, 1999].

2.2 Biopesticide: An excellent alternative of chemical pesticide

As we know pesticides are the toxic substances that kill the weeds, insects, fungus, and rodents. It is also used to manage the pest problem around the world [Lewis *et al.*, 1997]. Pesticides show a extensive range of human health risks from temporary to permanent impact. Among these conditions, acute conditions include nerve dysfunction, skin and eye irritation and long term chronic effects lead to cancer. In comparison to pesticides, bio pesticide are an eco-friendly nontoxic natural type of pesticides, derived from natural substances like plants, bacteria & minerals which has the capacity to control pests without affecting the environment. It was reported in 2014 that about 430 bio pesticides and 1320 active products has been registered for use in agricultural land [Roychowdhury *et al.*, 2014]. Bio pesticides have the properties like target pest specific and their close relatives, harmless to human beings and other beneficial organisms, and never cause pollution [Rabindra, 2005; Thakore, 2006]. So it is a major component of IPM (Integrated pest management) programme. According to the presence of different key components, bio pesticides are broadly classified as microbial bio pesticide (which include bacterial, fungal, viral), biochemical bio pesticide which include insect pheromone, different components of plant, growth regulatory hormone and the others are the formulated product of bio pesticide [Vinod *et al.*, 2015]. The challenges for bio pesticide industries are to develop a fruitful, safe and multifacted eco-friendly products

[Mukhopadhyay *et al.*, 1992; Kalra and Khanuja, 2007; Prabhat *et al.*, 2014].

2.2.1 Microbial bio pesticide

The active components in microbial bio pesticide are naturally evolved bacteria or genetically modified bacteria, fungi, viruses and protozoans. About 74% bacterial bio-pesticides, 10% of fungal pesticides, 5% of viral bio-pesticides and others include about 3% for all type of crops [Thakore, 2006]. Till now about 72 components of micro-organisms have been registered by USEPA (United States Environmental Protection Agency) which include 35 bacterial products, 15 fungal, 8 plants incorporated protectants (PIPs), 6 nonviable microbial bio-pesticides, 1 protozoan, 1 yeast and 6 viruses.

2.2.2 Biochemical pesticide

Biochemical pesticides are different from the conventional pesticide. The key components evolve naturally, a mixture comprising essential oil, insect pheromone etc. [Gelernter, 2006]. The hormone released from insects to communicate other members of same species is called as insect pheromones (semiochemicals). These chemicals are the type of decoder produced by the living organism or synthetic analogues which cause behavioural responses in the same or other species. The pheromones are used in pest management without killing the target pest but by attracting the pest towards the lethal pesticide or by initiating mating disruption. As it monitors the larger group of pest, it is the part of IPM system [Thakore, 2006]. The mixture of chemical component derived from plants and used as bio-pesticide are more diverse with respect to target pest, mode of action and their composition [Kovach *et al.*, 2012]. Different plant products have different modes of action on target organism: the fragrance of some plant extracts attract the toxic insects but other used as deterrent. Lemongrass oil, cause the degradation of some weeds. Some products cause suffocation while some other products increase the immune system of crops naturally. The important components for the proper growth of plants are plant hormones & growth regulators that accelerate or retard the growth of plant naturally. Along with bacterial bio-pesticide, fungal bio-pesticide, insect pheromone and some growth regulators of insect also alter the growth & development of insects, along with this some insecticides having juvenile hormone are also used [Vinod *et al.*, 2015]. Some chitin synthesis inhibitors are used as insecticide which decreases the ability of insect for further synthesis of new exoskeleton [Karen *et al.*, 2009].

2.2.3 Formulated Bio pesticides

The key components of formulated bio-pesticides are all the microbes and plant products. In case of bio-pesticide processing, some problems are related to presence of other inert ingredients along with the active ingredients.

Different survey have been carried out to study the particular bio-pesticidal effects on pests in various agricultural crops [Rahman & Motoyama, 2000] such as repellent as well as insecticidal effect from entire garlic clove, its rubbed product and buoyant extract of garlic on two stored products, maize weevil (*Sitophilus zeamais*) and red flour beetle (*Tribolium castaneum*). Alliin highly reactive and unstable volatile compound present in garlic is converted to allicin, pyruvate and ammonia by the activity of an enzyme called allinase when garlic is chopped [Salas, 2001]. These allicin have the aromatic property which repels the target pest, but the mechanism is unsure. From some studies it has been observed that some plant material like leaves of neem, pongum, citrus, nocli, tulsi, fly ash, castor oil, red earth are strongly effective on the survival of *C. Maculates* flourishing the green gram [Dhakshinamoorthy and Selvanarayana., 2002]. Different doses of neem (*Azadirachta indica*), Bergera (*Bergera koenigii*), akk (*Calotropis gigantea*), ipoma (*Ipoma reptans*), chilli (*Capsicum amanda*), and mustard (*Brassica campestris*) have the strong effects against *sitophilis oryzae* [Petel *et al.*, 2004]. Repulsive activities of some essential oil of aromatic plants were also analyzed by GC-MS (gas chromatography – mass spectrometry) against *sitophilus zeamais* (Coleoptera: curculionidae) [Nerio *et al.*, 2009].

2.2.4 Neem in Agriculture

Neem is considered as renewable resource with the potential in solving agricultural, environmental and public health problems. The common properties of neem are its non-toxicity; so they are beneficial in plant conservation and management. Neem derived products such as neem fruit, neem oil, neem seed cake and leaf extract used as bio-pesticide, fungicide and organic manure has been applied because of their different mode of action to control the insects, plant pathogen, pest which have the resistance against chemical pesticides. Studies say that neem can regulate around 300 species of insects. The most common form of neem used as pesticide in organic agriculture are the emulsifiable concentrate (EC) due to its biodegradable nature as well as it is easily mixes with synthetic pesticides and enhances their action. Now a day's dried neem extract is mixed with the stored grain, to prevent further proliferation of storage pest and even the insects stop feeding on them due to its anti-feeding property like, the most popular bio-pesticide Neem seed kernel extract (NSKE 5%) which is composed of well dried form of neem seed kernel, distilled water, detergent and neem oil (multineem) are used against chick pea pod borer *Helicoverpa armigera* [Bhatt and Patel, 2001]. Neem products intercede at various phases of the insect's life. The main function is to paralyze the activity of pests

instead of wiping out the pests. Due to the powerful insect growth regulatory (IGR) activity of different parts of neem, they are now recognised as more covetable product than a rapid clash synthetic pesticide in integrated pest management programmes. Not only Neem obeys all precedences among environmental objectives, this particular plant is also perhaps the utmost symbolic example of how nature can blend divergent activities *i.e.*, the action of de-oiled Neem cake as a pesticide cum fertilizer.

2.2.5 Neem as an Insecticide

Neem trees are invincible produce various defensive chemicals during pest attack which act as repellent, antifeedant, ovipositional deterrent, growth inhibitor, toxicant [Saxena *et al.*, 1989]. There are several application of different parts of neem tree in the field of ayurvedic medicine, as effective dentifrice [Larson, 1989], neem cake (remained part after oil extraction) as an effective fertilizer and animal feed. Azadirachtin (tetranortriterpenoid) one of the major active components which is the most potent natural insect antifeedant [Isman *et al.*, 1990]. It is a mixture of seven isomers named as Azadirachtin A-G. Among all, isomer E is most effective against insect growth regulator. Azadirachtin is highly unstable and stored at -40°C are not applied directly to the field. Oil based extracts stabilize these biologically active compounds. So the commercial azadirachtin preparation is more advantageous over pure azadirachtin [Isman *et al.*, 1990a].

Neem extract has been used in over 195 insect species and some rebellious insects are also controlled by the neem extract application [Salma *et al.*, 2011]. Formulated neem product has significant effect against eggs of peach fruit fly (*Bactrocera zonata*) but has no effect on good insects like pollinator insects, bees and other useful organism [Salma *et al.*, 2011]. The insecticidal effect of Botanical toxin (*Bacillus thuringiensis*) and agricultural insecticide (*Azadirachta indica* and *Vitex negundo*) on the lactate dehydrogenase enzymatic activity in rice leaf folder called as Guenee (*Cnaphalocrocis medinalis*) was studied [Nathen *et al.*, 2006]. The combined effect of both bacteria and insecticides even in low concentration decreases the LDH activity strongly. This indicates that combinational product is an efficient enzyme inhibitor [Kumar, 2015].

Some of the studies are done by using aqueous form of neem seed powder on the survival, improvement and growth of Aphid (*Aphis gossypii*) Glover which is the most perinicious pest on cotton causing direct or indirect loss [Chinaberry and Jehu, 2001]. This aphid normally live superficially on leaves, feed the phloem part and causes around 50 types of diseases in plant. Biological insecticides are used against these aphids instead of using

aphid resistant chemical pesticide [Weathersbee, 1997; Kabissa *et al.*, 1996; Mann *et al.*, 2001]. The negative effects of different concentration of azadirachtin on different parameters like development & survival of nymph, number of molts of aphids *A. gossypii* has been checked [Stark and Rangus, 1994]. It was found that the fertility of various aphids like *A. pisum* on faba bean [Stark and Rangus, 1994; Stark and Wennergren, 1995] and *Myzus persicae* on sweet pepper were reduced at the highest concentration of neem extract. Neem extracts show high mortality rate, decreasing fertility, growth inhibitory activity on more than 400 insect species from different orders like Diptera, Hymenoptera, Coleoptera, Lepidoptera, orthoptera and Hemiptera etc [Ragsdale *et al.*, 2004; Liu *et al.*, 2004]. As neem extract is efficient to control several aphids in the field, so these are the most significant product to be used as biological pesticide.

The neem product Azadirachtin affect the activity of enzyme ecdysone by suppressing the moulting or ecdysis process of insects by entering into insect's larva through feeding and restrict the passage of larva to pupal stage, thus leading to death. The different parameter like survivorship, development, fecundity of soybean aphid (*Aphis glycine*) and its predator named *Harmonia axyridis* are also are affected by the action of neem seed oil and azadirachtin. Azadirachtin & neem seed oil are two key components which have been proven most fruitful agent, against the aphids like Brown citrus aphid, *Toxoptera citricida* (Kirk lady) by increasing in nymph as well as adult mortality and decreasing adult fecundity in all trial concentration [Tang *et al.*, 2002]. Along with this, neem seed oil has some muffling effect on pea aphid, *Acyrtosiphon pisum* (Harris) nymphal mortality [Stark and Walter, 1995]. Based on the aphid mortality neem oil and its processed product are more efficient than azadirachtin [Adan *et al.*, 1998].

2.2.6 Neem as an ovipositional deterrent

Neem (*Azadiracht indica*, A.Juss, Meliaceae) as a plant based pesticides [Elisinary and Rizk, 2002] has an ovipositional deterrent activity on some pest like *Bactrocera carambolae* (fruit fly) which decreases economic value of fruits and vegetables. It is also used against the cabbage moth, *Mamestra brassicae* [Joger *et al.*, 2009], peach fruit-fly (*B. Zonata*) [Mohamoud and Shoeib, 2008] and potato tuber moth, *phthorimaea operculella* [Elsinary and Rizk, 2002]. It has been found that neem leaves contain more polar components and the most dominant component found in n-hexane extract of neem is nonacosane, which is made up of a group of saturated fatty acid having the negative impact on egg as well as egg producing capacity and durability of larvae of *Stephanities pyriodes* [Wang *et al.*, 1999]. Nonacosane

attracts different parasitoid like *Trichogramma chilonis* [Ananthakrishnan *et al.*, 1991], *T. Briasiliensis* and *T. exiguum* [Kumar *et al.*, 2011] and *Cotesia plutellae* [Kumar *et al.*, 2012; Seenivasagan and Paul, 2011].

2.2.7 Neem as Biofungicide

Neem oil is used as fungicide, to prevent the germination of fungal spores. The neem based products are used as natural biofungicide in the branch and collar canker disease caused by tea plant pathogen. The extracts of neem have a suppressive effect on the fungal pathogen like *Poriamonticolad* infecting wood [Dhyani *et al.*, 2004], *Pyricularia oryzae* infecting rice plant [Amadioha, 2000]. Components like Azadirachtin, nimbin, nimbidin and also some commercially available neem product like Achook, Bioneem, Nimbecidine, Neemark have the antifungal property against some pathogen like *Fusarium oxysporium*, *Altanaria solani*, *Curvulata lunata*, *Helminthosporium* sp. and *Sclerotium rolfsii* [Bonder *et al.*, 1999]. Azadirachtin has significant inhibitory effect on the plant pathogenic fungi and acts as a most advance fungicide than Bavistin and mancozeb, the synthetic fungicide [Dubey and Kumar, 2009]. Beside this, neem oil also has the fungicidal property on some fungi like *Botryiscinera* and *Glomerella cingulata* [Hirose *et al.*, 2001]. Among the commercially available neem products, Nimbecidine is the oil based pesticide where the active ingredients are azadirachtin and other components like melianthol, salnin, nimbin are used against the worms, weevils and wire worms of tomatoes [Schumutterer, 1990]. Another component of neem is Trilogy which is a clarified hydrophobic extract of neem oil, has multiple properties like insecticide, acaricide and fungicidal effect against the mildews on cucurbits [Meister, 1999]. It also acts as a growth regulatory agent and represses the growth of pathogen like *Podosphaera xanthii* on cucumber leaves [Aboellil, 2007]. Trilogy is more effective in bacteria like *Pseudomonas xanthii* at very low concentration as reported by [Polioakidou, 2005]. The growth inhibitory effect of nimbecidine is more than that of Trilogy in their higher concentration. Nimbecidine has an adverse effect on the growth parameter of *P. theae* and can be used by the farmers in the management of pest [Okigbo and Nmeke, 2005].

III. CONCLUSION

Now there is a need of cost effective, biodegradable, eco-friendly and potential, soft pesticide in agriculture field. As neem act as the most reliable source of pro-pesticide having no ill effect on human and animals, on agricultural product. So neem is used as organic fertilizer and pesticide for sustainable crop production. Neem based products play a crucial role in pest management, which acts across different pests of both crop field as well as

stored grains like rice, wheat, corn, legumes, potato, tomato *etc.*

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